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Effect of the lithium ions on the structure formation of the ceramics based on sodium niobate

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The structure of sodium, potassium and lithium niobate ceramics and complex oxides based on them was studied. Ceramic samples were prepared by solid-phase synthesis method from alkali metal carbonates KCO_3, $NaCO_3$, $LiCO_3$ and niobium pentoxide Nb_2O_5 by traditional ceramic technology. Sintering was carried out at a temperature of 1100 ºC except of potassium niobate (700 ºC). The ceramics structure was studied by scanning electron microscope (SEM) JEOL JSM 6610 LV in the secondary electron mode. Studies of the domain structure and local piezoelectric loops were carried out by piezoresponse force microscopy (PFM) at room temperature on a SolverNano (NT-MDT).

These oxides are octahedral type oxides with the general formula ABO_3, where the position of A can be occupied by ions of Li, Na, K. As can be seen in Figure 1, the shape and size of the grains depend on the type of ion in position A. In the case of potassium niobates the shape is cubic, as well as for solid solution of potassium sodium niobate. The main difference is the grain size (Fig. 1a,e). The lithium niobate ceramics grains have irregular shape (Fig. 1c), as a result they contact more closely. And sodium niobate ceramics grains have spherical shape (Fig. 1b).

The addition of 10% lithium ions to $KNaNb_2O_6$ ceramics leads to a strong increase in the size of the grains (Fig. 1e,f), but they retain their cubic shape. In the case of addition of 10% lithium ions to $NaNbO_3$ ceramics grains remain spherical (Fig. 1d). Furthermore, the addition of lithium to both the $KNaNb_2O_6$ and $NaNbO_3$ ceramics leads to an increase the density and hardness of ceramics samples. At the same time the presence of potassium ion in position A is associated with the cubic shape of grains.

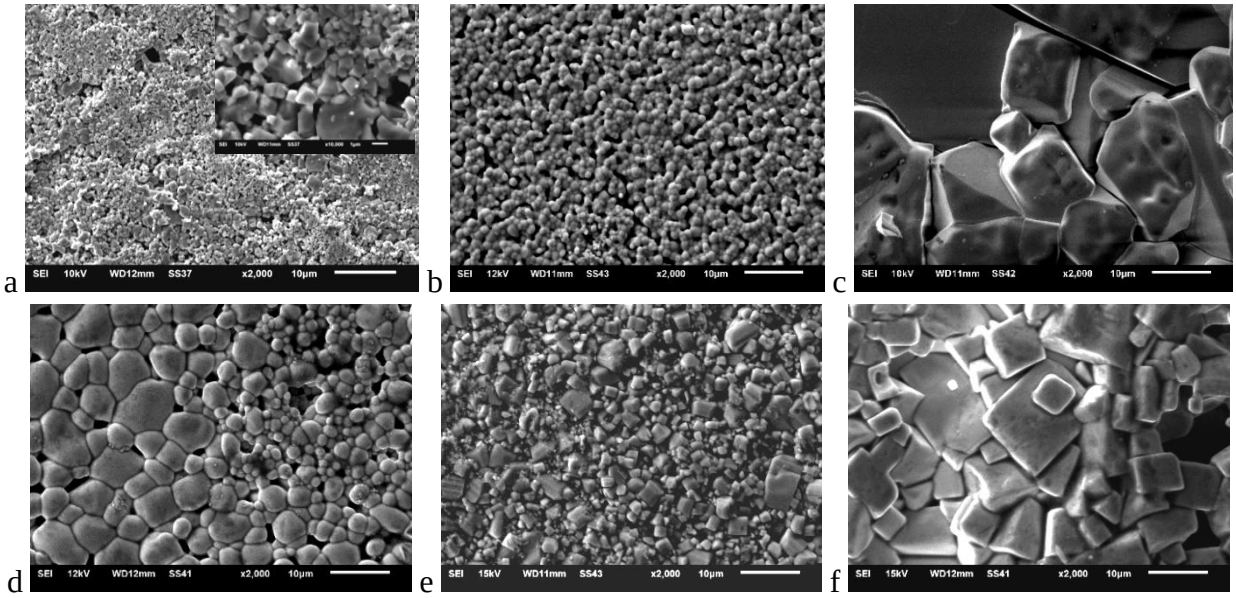

Figure 1. SEM image of (a) $KNbO_3$, (b) $NaNbO_3$, (c) $LiNbO_3$, (d) $Li_{0.1}Na_{0.9}NbO_3$, (e)$KNaNb_2O_6$, (f) $Li_{0.1}(NaK)_{0.9}Nb_2O_6$ ceramics. Scale 10 μm: (a) inset scale 1 μm.